PATENT

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application: Smith, et al.

Serial No: 09/943,644

Filed: August 30, 2001

For: Fluoropolymer Compositions, Optical Devices, and Methods For Fabricating Optical Devices

Examiner: M. Angebranndt

Art Unit: 1756

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Commissioner of Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Appellants submit herewith the following Brief on Appeal in accordance with 37 C.F.R. §1.192:

1. Real Party in Interest

The real party in interest in this matter is the Assignee of Record, Clemson University.

2. Related appeals and interferences

There are no other appeals or interferences known to the Appellant or the Appellant's legal representative which will directly affect or be directly effected by or have a bearing on the Board's decision in the pending appeal.

3. Status of the Claims

Claims 16, 18, 19, 22-26, 28, 29, and 36-44 are currently pending in the present application, including independent claims 16, 28, and 29. Claims 1-15, 17, 20-21, 27, 30-35, and 45-47 have been previously canceled from the application. All of the

pending claims have been rejected and are hereby appealed. All of the pending claims are attached hereto as Appendix A.

According to the Advisory Action dated October 9, 2002, the remaining claims stand rejected under 35 U.S.C. §103(a) as being unpatentable over Smith, et al. (J. Fluorine Chemistry, Vol. 104(1), pp. 109-117, 2000), Babb, et al. '164 (U.S. Patent No. 5,426,164), or Babb, et al. '038 (U.S. Patent No. 5,159,038), in view of Kennedy, et al. (U.S. Patent No. 5,246,782), Fischbeck, et al. (Electron. Lett., Vol. 33(6), pp. 518-519, 03/97), further in view of Shacklette, et al. (U.S Patent No. 5,850,498), Shah, et al. (Polym. Mater. Sci. & Eng, 2000, Vol. 82, p. 300) and Kaneko, et al. (U.S. Patent No. 6,438,307).

4. Status of Amendments

All amendments filed thus far have been entered into the record by the Examiner.

5. Summary of the Invention

A method for making an optical device and the optical devices formed thereby are provided. The method may include the steps of: providing a perfluorocyclobutyl-based (PFCB) copolymer composition, coating the perfluorocyclobutyl-based copolymer composition upon a substrate to form a first film, and thermally curing the first film to form a thermoset film. (Page 4, lines 25-30). In one aspect of the invention, optical devices and a process for fabricating optical devices may include an optical waveguide constructed of a core region and a clad region (Page 6, lines 15-17). An optical waveguide is a waveguide which guides radiation in the visible and near-visible portions of the spectrum by means of total internal reflection. The optical waveguides of the pending claims include a low refractive index sheathing or covering, a clad, that covers a higher index of refraction PFCB copolymer core. The clad layer operates to confine light in the PFCB copolymer core by means of total internal reflection.

The coatings (i.e., individual films formed by some coating process) formed by the process may be patterned by lithography, reactive ion etching ("RIE"), electron beam methods, or micromolding. The first layer structures may be coated more than once until a core/clad optical device is formed that is multilayered. (Page 9, lines 7-12.)

In the practice of one aspect of the invention, it is possible to copolymerize specific comonomers to provide variable and relatively thick core and clad copolymers for waveguide applications (Page 8, lines 21-23).

In summation, the process can include forming (by known coating methods) a film. This film can then be patterned as described to form the structure of the first layer of the device. This layer may then be covered (i.e., coated) with another material to form the next layer of the core/clad device. Additional layers can then be added as desired. All of the claims are directed to a core/clad device or a process of making a core/clad device that include a PFCB copolymer core and a clad. In one embodiment, the clad can also be formed of a PFCB copolymer material, though the clad material will not be the same copolymer as the core material, as the clad material must have a lower refractive index than the core material.

The invention is capable of providing well defined cyclopolymerization mechanisms using PFCB to prepare copolymers with tunable thermal and optical properties. For example, random amorphous copolymers with variable refractive indices, glass transition temperatures, and long term thermal stability above 350°C may be prepared by correct choice of a co-monomer composition. Copolymers may be prepared by simple melt mixing of variable composition monomer mixtures and heating under appropriate conditions. Using the invention, it is possible under some conditions to provide for precise control of refractive index by the choice of co-monomer that is used. (Page 6, lines 2-11.)

As mentioned above, in the practice of one aspect of the invention, it is possible to copolymerize specific comonomers to provide variable and relatively thick core and clad copolymers for waveguide applications. By thick, it is meant having a thickness of at least about 0.6 microns. In some applications, a thickness of 1 micron or more may be achieved in only one coat. In other preferred embodiments of the invention, a thickness of at least about 2 microns may be achieved. Thickness levels from 2-10 microns also can be achieved, and in some aspects of the invention, it may be possible to achieve thickness levels well over 10 microns, up to and including at least about 50 microns in some particular embodiments of the invention. The solution processability of the compositions in the practice of the invention is especially favorable. A reactive

copolymer is provided which can be dissolved in very low amounts of solvent so that especially thick coatings can be prepared. (Page 8, line 21 – Page 9, line 6.)

PFCB copolymers are prepared from trifluorovinyl aromatic ether monomers via a free radical mediated thermal co-polymerization mechanism as illustrated in Figure **1**. A representative example of some of the groups that may be included and used as the Ar and/or Ar' group of the copolymers as shown in Figure **1** are included in Figures **2A-2I**.

6. Summary of the Issues

I. Are claims 16, 18, 19, 22-26, 28, 29, and 36-44 unpatentable under 35 U.S.C. §103(a) over Smith, et al. in view of Kennedy, et al., Fischbeck, et al., Shacklette, et al., Shah, et al., and Kaneko, et al.?

   A. Can the teachings of Smith, et al., Kennedy, et al., Fischbeck, et al., Shacklette, et al., Shah, et al., and Kaneko, et al. be properly combined and/or modified as suggested?

II. Are claims 16, 18, 19, 22-26, 28, 29, and 36-44 unpatentable under 35 U.S.C. §103(a) over Babb, et al. '164 in view of Kennedy, et al., Fischbeck, et al., Shacklette, et al., Shah, et al., and Kaneko, et al.?

   A. Can the teachings of Babb, et al. '164, Kennedy, et al., Fischbeck, et al., Shacklette, et al., Shah, et al., and Kaneko, et al. be properly combined and/or modified as suggested?

III. Are claims 16, 18, 19, 22-26, 28, 29, and 36-44 unpatentable under 35 U.S.C. §103(a) over Babb, et al. '038 in view of Kennedy, et al., Fischbeck, et al., Shacklette, et al., Shah, et al., and Kaneko, et al.?

   A. Can the teachings of Babb, et al. '038, Kennedy, et al., Fischbeck, et al., Shacklette, et al., Shah, et al., and Kaneko, et al. be properly combined and/or modified as suggested?

7. Grouping of the Claims

It is to be understood that this appeal is of all claims, each individually patentable. The rejected claims do not stand or fall together. The following claim

groupings make an effort to simplify the appeal by gathering common elements of Appellant's claims into groupings which will be discussed herein.

Group	Claims Included	
1	16, 19, 22-26, 29, and 36	Directed to an optical waveguide including a PFCB copolymer core and a clad (grouping includes both method and product claims).
2	18, 28, and 37-44	Directed to an optical waveguide including a PFCB copolymer core and a second PFCB copolymer clad (grouping includes both method and product claims).

8. Argument

I. Claims 16, 18, 19, 22-26, 28, 29, and 36-44 are patentable under 35 U.S.C. §103(a) over Smith, et al. in view of Kennedy, et al., Fischbeck, et al., Shacklette, et al., Shah, et al., and Kaneko, et al.

A. The teachings of Smith, et al., Kennedy, et al., Fischbeck, et al., Shacklette, et al., Shah, et al., and Kaneko, et al. cannot be properly combined and/or modified as suggested.

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art and not based on applicant's disclosure. (*In re Vaeck,* 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991)).

The primary reference in this rejection is Smith, et al. Smith, et al. discusses formation mechanisms for PFCB polyaryl ethers. Specifically, the reference discusses the development of an intermediate strategy utilizing Grignard and aryllithium reagents which offers access to a wide variety of hybrid materials amenable to coatings applications (Abstract). The PFCB polymers (including both homopolymers and

copolymers) of Smith, et al. are described as being candidates for applications such as high performance structural coatings, interlayer dielectrics, circuit board laminates, dielectric waveguides, optical cladding layers, and coatings for space applications, as described in the final six lines of the first column of the article. Smith, et al. does not, however, disclose the copolymer materials as being possible core material in a core/clad optical waveguide as is taught in all of the pending claims.

In addition, while Smith, et al. does disclose spin coating a mesitylene solution of monomer 1 and forming a cured film of 3-6 μm (see page110, second column - comparison of the Raman spectra of pure monomer 1, an oligomeric film spin coated on silicon, and a fully cured 3-6 μm film), Smith, et al. discloses only the formation of the copolymers in solution (see, for example, page 114, second column) and does not disclose methods of forming a film of the copolymer materials. For instance, Smith, et al. does not disclose methods of forming a core/clad device including coating a PFCB copolymer composition on a substrate to form a film, thermally curing the film to form a polymeric core and coating a second composition on the outer surface of the core to form a clad, as taught in, for example, claim 16 of Group 1. In addition, Smith, et al. does not disclose or suggest forming a PFCB copolymer film to form a core of an optical device and a different PFCB copolymer film coated on the first film to form a clad of an optical device, as is found in the claims of Group 2.

In the rejection of the claims, Smith, et al. has been combined with five other references to arrive at the claimed invention. The Federal Circuit has several times reiterated that the determination of obviousness cannot be based on the hindsight combination of components selectively culled from the prior art to fit the parameters of the patented invention (*Crown Operations International, Ltd. V. Solution, Inc.*, 289 F.3d 1367 62 USPQ2d 1917 (Fed.Cir. 2002)). When patentability turns on the question of obviousness, the search for and analysis of the prior art includes evidence relevant to the finding of whether there is a teaching, motivation, or suggestion to select and combine the references relied on as evidence of obviousness (*In re Lee*, 277 F.3d 1338, 61 USPO2d 1430 (Fed. Cir. 2002)). Appellants respectfully submit that this doctrine has not been properly applied in arriving at the suggested combinations.

For example, in the Final Office Action, Fischbeck, et al. was combined with Smith, et al. and Kennedy, et al. (at 16). Fischbeck, et al. describes a TVE-PFCB homopolymer and presents the loss spectrum measured on a single mode waveguide formed of the material. The waveguiding homopolymer of Fischbeck, et al. is spin coated with a thickness of 3.6 μm onto a silicon substrate and cured. In the Final Office Action (at 16) it was stated that, "it would have been obvious to one skilled in the art to coat other TVE-PFCB polymers, such as those disclosed by Smith et al. to the thicknesses disclosed by Fischbeck et al. to evaluate their optical properties and potential as waveguiding materials based upon the desirable properties evidenced in Fischbeck et al." (citations omitted). Appellants respectfully submit that the suggested combination is, at best, motivated by an "obvious to try" test. The motivation, that of evaluating properties and potential usage of materials, cannot be considered more than a suggestion to further explore the materials. It is even more evident that the suggested combination rises no higher than a possible "obvious to try" combination in light of the teaching of the other references. For instance, in Shah, et al., a single PFCB copolymer is shown to have quite different characteristics, including the number average molecular weight and the weight average molecular weight, as compared to the PFCB monomers in the reference. In addition, other information concerning the copolymer (for example ε, the dielectric constant) had not even been determined yet according to Shah, et al. The courts have many times upheld the doctrine that a determination of obviousness cannot be based on what the skilled person might try or find obvious to try, but rather on what the prior art would have led the skilled person to do. "Both the suggestion and the expectation of success must be founded in the prior art, not in the applicant's disclosure." (*In re Dow Chemical Co. v. American Cyanamid Co.*, 837 F2d at 471, 5 USPQ2d at 1530). Absent the present disclosure, there is no suggestion found in the references to process and utilize the PFCB co-polymer materials to form the core of a core/clad optical waveguide.

In the Advisory Action dated October 9, 2003, Shacklette, et al., Shah, et al., and Kaneko, et al. were cited as describing various thicknesses, properties and materials for the cladding layer and applied to the teachings of the other references to provide information concerning the clad to the combination.

Shacklette, et al. is directed to low stress optical waveguide assemblies wherein one or more waveguide cores have a conformal cladding attached. Flexible, low glass transition temperature polymers are used to form the core of the devices, preferably multifunctional acrylate monomers (col. 5, lines 53-63). The materials are photopolymerizable compounds, and in a preferred embodiment, the core has a glass transition temperature less than about 80°C and the cladding has a glass transition temperature less than about 60°C (col. 7, lines 45-54). Appellants respectfully submit that there is no motivation or suggestion that the teachings of Shacklette, et al., directed to optical devices formed of low T_g photopolymerizable polymers, may be in any proper way combined with the teachings of Smith, et al., which teaches not only thermally curable materials, but also the preference for high glass transition temperature materials throughout the article. In fact, Appellants submit that the references themselves teach against any combination, in particular as Smith, et al. is specifically directed to high T_g materials and teaches the preference of high T_g materials over low T_g materials, such as those taught by Shacklette, et al.

In the Office Action dated April 23, 2003 (at 17), it was stated that Kaneko, et al. teaches that the polymers used in the core and cladding layers may be the same materials or different. However, Appellants submit that Kaneko, et al. cannot properly be combined with the other references, and in particular with Smith, et al., as suggested. The optical waveguides of Kaneko, et al. are optical devices including a core, an adjacent clad and an optional outer clad. The material utilized to form the core and the immediately adjacent clad of the optical devices of Kaneko, et al. is a single material whose refractive index is varied corresponding to the irradiation amount of light. The clad material immediately adjacent to the core is the same siloxane polymer as that which forms the core. A single solution is spin coated on the lower cladding, and the part of this layer which is to be the core is shielded with photomasks while the regions to be the clad are irradiated with UV rays (see Examples 1 and 2). The materials of Smith, et al., on the other hand, are completely different. Specifically, the materials of Smith, et al. are not photopolymerizable materials whose refractive index varies corresponding to the irradiation amount of light but are thermally curable materials whose refreactive

index is defined by their chemical make-up. As such, Appellants respectfully submit that there is no motivation to combine the teachings of the two references as suggested.

Moreover, Appellants further submit that the teachings of these two references could not be combined without rendering the prior art unsatisfactory for its intended purpose. For example, Smith, et al. forms a homopolymer PFCB film by fully curing the film under nitrogen or air at temperatures ranging from 235°C to 325°C for several hours (page 110, column 2). Kaneko, et al. forms a core and adjacent clad by heat treating a spin coated siloxane polymer at 100°C for 30 minutes (to evaporate the solvent), followed by irradiating the layer with UV at an irradiation amount of light of about of 100mJ/cm^2, followed by irradiating only that portion of the layer to form the clad with UV rays at an irradiation amount of light of 1,500 mJ/cm^2 (Examples 1 and 2). Utilizing the materials of Smith, et al. according to the process of Kaneko, et al. would not allow the thermo-curable materials of Smith, et al. to cure. Utilizing the materials of Kaneko, et al. according to the process of Smith, et al. would not properly cure the photopolymerizable materials of Kaneko, et al. as taught in the reference.

Similarly, Appellants submit that there is no proper motivation to combine all of the secondary references with each other. For example, there is no motivation to combine Kaneko, et al. or Shacklette, et al., both generally directed to optical waveguides formed of photopolymerizable polymers with Kennedy, et al., Shah, et al., or Fischbeck, et al. all of which are directed to various applications of thermally curable polymers. Similarly, there is no motivation to combine Shacklette, et al., generally directed to low T_g materials, with the teachings of Kennedy, et al., Shah, et al., or Fischbeck, et al., all directed to high T_g materials.

For at least these reasons, Appellants respectfully maintain that the pending claims patentably define over the combination of Smith, et al., Kennedy, et al., Fischbeck, et al., Shacklette, et al., Shah, et al., and Kaneko, et al.

II. Claims 16, 18, 19, 22-26, 28, 29, and 36-44 are patentable under 35 U.S.C. §103(a) over Babb, et al. '164 in view of Kennedy, et al., Fischbeck, et al., Shacklette, et al., Shah, et al., and Kaneko, et al.

A. The teachings of Babb, et al. '164, Kennedy, et al., Fischbeck, et al., Shacklette, et al., Shah, et al., and Kaneko, et al. cannot be properly combined and/or modified as suggested.

Babb, et al. '164 is directed to a photoimageable polymer which has at least one photoactive site and more than one perfluorocyclobutane group. The polymers are useful in coatings, photoresists, and the like (Abstract). The photoactive polymers prepared by the disclosed methods are advantageously used as coatings (col. 20, lines 13-14), and specifically for use as a negative photoresist (col. 22, line 24), or as scratch resistant or chemically resistant coatings on optical lenses or other devices where optical transparency is an important feature (col. 22, lines 56-60). While Babb, et al. '164 teaches the applicability of the materials for outer protective coatings applications, there is no teaching found in Babb, et al. '164 that the polymers may be used as the core material in a core/clad optical device as is taught in presently pending claims.

The secondary references used in this rejection are the same as those used above. Appellants respectfully submit that this rejection is not proper for at least those reasons given above in regard to the improper combinations of the secondary references. However, and in addition, Appellants further submit that the primary reference of this particular rejection, Babb, et al. '164, cannot properly be combined with all of the secondary references as suggested. For example, and as discussed above in relation to Smith, et al., the combination of Babb, et al. '164 with Fischbeck, et al. is at best motivated by an "obvious to try" test, which is not a proper test for obviousness.

In addition, even if Babb, et al. '164 was to be combined with Fischbeck, et al. and the other four references, absent proper motivation to do so, the suggested combination would still not teach or suggest all of the elements of the claims at issue. For instance, the polymers of Babb, et al. '164 have at least one photoactive site such that the polymer becomes less soluble or dispersible in at least one solvent or dispersing medium than it was before exposure to the incident photonic radiation (col. 2, lines 48-53). If the polymers disclosed by Babb, et al. '164 were coated to the thicknesses disclosed by Fischbeck, et al., as suggested, the combination would provide a single mode optical waveguide formed of a polymer having at least one photoactive site. The core materials of the core/clad devices of the pending claims, in

contrast, are thermally curable materials, and do not include a photoactive site, as would be obtained by the suggested combination.

As such, and for at least these reasons, Appellants respectfully maintain that the pending claims patentably define over the combination of Babb, et al. '164, Kennedy, et al., Fischbeck, et al., Shacklette, et al., Shah, et al., and Kaneko, et al.

III. Claims 16, 18, 19, 22-26, 28, 29, and 36-44 are patentable under 35 U.S.C. §103(a) over Babb, et al. '038 in view of Kennedy, et al., Fischbeck, et al., Shacklette, et al., Shah, et al., and Kaneko, et al.

A. The teachings of Babb, et al. '038, Kennedy, et al., Fischbeck, et al., Shacklette, et al., Shah, et al., and Kaneko, et al. cannot be properly combined and/or modified as suggested.

Babb, et al. '038 is directed to a process for preparing a polymer having PFCB rings. Exemplary products of the patent include low dielectric fluids and lubricants (col. 2, line 68). The secondary references used in this rejection are the same as those used above. Appellants respectfully submit that this rejection is not proper for at least those reasons given above in regard to the improper combinations of the secondary references. However, and in addition, Appellants further submit that the primary reference of this particular rejection, Babb, et al. '038, cannot properly be combined with all of the secondary references as suggested. For example, Babb, et al. '038 does not disclose or suggest any uses of the polymers related to optical devices, to which the teachings of Kaneko, et al., Shacklette, et al., and Fischbeck, et al. are all directed. Moreover, the materials of Babb, et al. '038 are thermally curable polymers, and not photopolymerizable, as are the materials of Kaneko, et al. and Shacklette, et al. As discussed above in relation to Smith, et al. and Babb, et al. '164 while the combination of Babb, et al. '038 with Fischbeck, et al. may, at best, be motivated by the improper "obvious to try" test, based at most upon similarity of specific chemical constructions pulled from the references, Appellants can discern no incentive at all for the combination of, for example, Babb, et al. '038, directed to polymers for use as lubricants and low dielectric fluids, with Shacklette, et al., directed to optical devices formed of

photopolymerizable polymers, or Babb, et al. '038 with Kaneko, et al., directed to optical devices formed of photopolymerizable polymers.

As such, and for at least these reasons, Appellants respectfully maintain that the pending claims patentably define over the combination of Babb, et al. '038, Kennedy, et al., Fischbeck, et al., Shacklette, et al., Shah, et al., and Kaneko, et al.

In conclusion, in order to render obvious the present claims as suggested by the Examiner, one of ordinary skill in the art would first have to combine six (6) separate references together in a specific manner absent proper motivation to do so. Due to the large number of different combinations of references required in the above rejections, and for the sake of brevity, Appellants have not included every possible argument illustrating all improper combinations of the references. However, for at least the above reasons, Appellants maintain that one of ordinary skill in the art would not have undertaken the first step, i.e., combining or modifying six separate references to achieve the limitations of the present claims. As such, Appellants respectfully submit that the present claims patentably define over the cited references, and that the present application is in complete condition for allowance. As such, Appellants respectfully request issuance of a patent.

Respectfully submitted,
DORITY & MANNING, P.A.

Christina L. Mangelsen
Registration No. 50,244

DORITY & MANNING, P.A.
P. O. Box 1449
Greenville, SC 29602-1449
Phone: (864) 271-1592
Facsimile: (864) 233-7342

Dated: 11/21/03

Appendix A

Listing of claims involved in this Appeal:

16. A method of making an optical device, comprising:

(a) providing a perfluorocyclobutyl-based copolymer composition having a solids content of greater than 50%,

(b) coating the perfluorocyclobutyl-based copolymer composition upon a substrate to form a first film,

(c) thermally curing the first film to form a thermoset film, in which the thermoset film comprises a substantially transparent polymeric core of an optical waveguide, and

(d) coating a second composition on the outer surface of the first film to form a second film, in which the second film is a clad of the optical waveguide.

18. The method of claim 16 wherein the second composition comprises a second perfluorocyclobutyl-based copolymer.

19. The method of claim 16 in which the coating steps are accomplished by spin coating.

22. The method of claim 16 in which the perfluorocyclobutyl-based copolymer composition is applied to the substrate in a solution having at least about 60% solids by weight.

23. The method of claim 16 in which the perfluorocyclobutyl-based copolymer composition is applied to the substrate in a solution having at least about 70% solids by weight.

24. The method of claim 16 in which the cured first film comprises a thickness of at least about 1 micron.

25. The method of claim 16 in which the cured first film comprises a thickness of at least about 2 microns.

26. The method of claim 16 in which the cured first film comprises a thickness of at least about 3 microns.

28. A method of making an optical device, comprising:

providing a first perfluorocyclobutyl-based copolymer composition,

spin coating the first perfluorocyclobutyl-based copolymer composition upon a substrate to form a first film, wherein the first film forms a substantially transparent polymeric core,

providing a second perfluorocyclobutyl-based copolymer composition comprising a second perfluorocyclobutyl-based copolymer different than the first perfluorocyclobutyl-based copolymer, and

spin coating the second perfluorocyclobutyl-based copolymer composition upon the first film to form a second film, wherein the second film forms a polymeric clad.

29. An optical device constructed by the method of:

(a) providing a perfluorocyclobutyl-based copolymer composition having a solids content of greater than 50%,

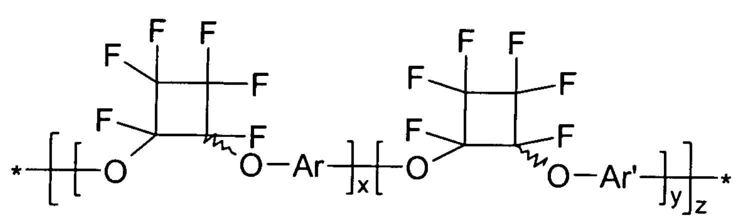
(b) spin coating the perfluorocyclobutyl-based copolymer composition upon a substrate to form a first film, wherein the first film forms a core for an optical device having a cured film thickness of at least about 0.6 microns, and

(c) spin coating a second composition on the outer surface of the first film to form a second film, in which the second film is a clad of the optical device.

36. The method of claim 16, wherein the thickness of the thermoset film is between about 10 and about 50 microns.

37. The method of claim 28, wherein the first film and the second film are each about at least about 10 microns thick.

38. The method of claim 28, wherein the first and second copolymer compositions comprise perfluorocyclobutyl-based copolymers having the structural formula:



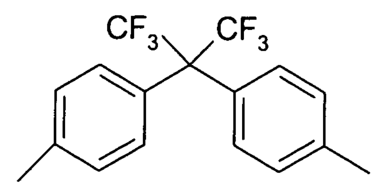
wherein Ar does not equal Ar',

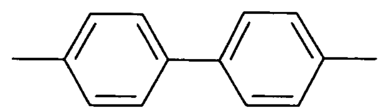
wherein z is greater than or equal to 2, and

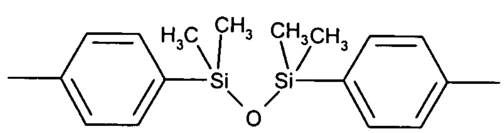
wherein x and y each are greater than or equal to 1, respectively.

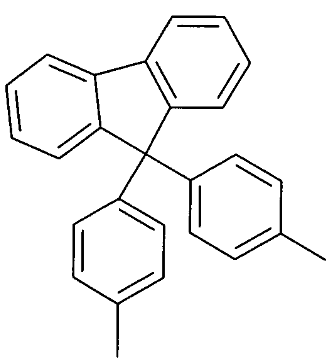
39. The method of claim 38, wherein at least one of Ar or Ar' is a trifluorovinyl aromatic ether.

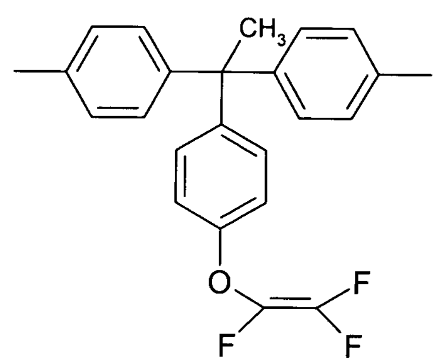
40. The method of claim 38, wherein the Ar and the Ar' groups each comprise substituted or nonsubstituted aryls selected from the group consisting of:

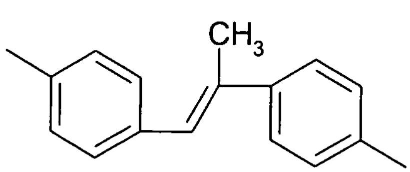


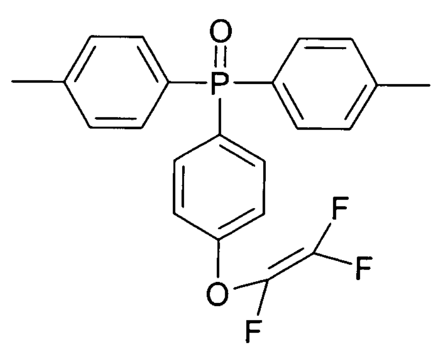


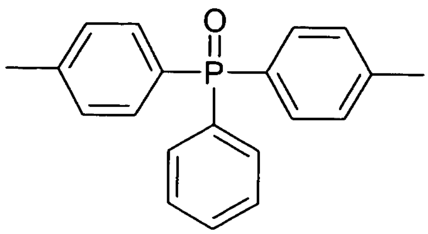


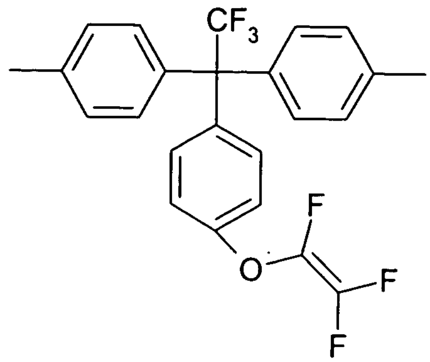










, and .

41. The optical device of claim 29, wherein the second film comprises a second thermoset perfluorocyclobutyl-based copolymer, wherein the second film is a clad for the optical device having a cured film thickness of at least about 0.6 microns.

42. The optical device of claim 41, wherein the first film and the second film each have a thickness of at least about 5 microns.

43. The optical device of claim 41, wherein the first film and the second film each have a thickness of at least about 10 microns.

44. The optical device of claim 41, wherein the first film and the second film each have a thickness between about 10 and about 50 microns.